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FAX COVER SHEET FOR MESSAGE FROM:

Kent N. Stone, Patent Attorney
NASA Glenn Research Center
Mail Stop: 500-118
21000 Brookpark Road
Cleveland, Ohio 44135

Voice telephone: (216) 433-8855 FAX: (216) 433-6790

e-mail: k.n.stone@grc.nasa.gov

TO: Ed Look, Director, USPTO Group 3745

DATE: October 18, 2002

MESSAGE

RE: Application Ser. No. 09/498,794

Per our telephone conversation this morning, following is the "Petition to Accept Missing Item in New Application" and its Attachments, including page 7, which I filed by Express Mail on 4-24-00.

The first page transmitted is the Customer Copy of the U.S. Postal Service Express Mail Label No. EJ596690436US .

V/R

Kent N Stone

Kent N Stone
Reg. No. 31,883

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FROM: (PLEASE PRINT) PHONE (216) 433-8855
Kent N. Stone, Patent Attorney
NASA Glenn Research Center
Office of Chief Counsel
21000 Brookpark Rd.
Cleveland, Ohio 44135

TO: (PLEASE PRINT) PHONE
Assistant Commissioner for Patents
Petitions Office
Box: DAC (Fee)
Washington D.C. 20231

FOR PICKUP OR TRACKING CALL 1-800-222-1811 www.usps.gov

Label 11-B July 1997

LEW 16,833-1 : Petition Filed by Express Mail
4-24-2000

#6

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of Duffy, et al
Attorney's Docket No. LEW 16,833-1
Serial No. 09/498,794
Filing Date: 02/01/2000
For: "Self-Tuning Impact Damper for Rotating Blades"
Group Art Unit: 3745

Assistant Commissioner for Patents
Attn: Petitions Office
Washington D.C. 20231
Box: DAC (Fee)

PETITION TO ACCEPT MISSING ITEM IN NEW APPLICATION UNDER 37 CFR 1.182

A. Petitioner, the National Aeronautics and Space Administration, an agency of the federal government, respectfully requests that the Commissioner grant this petition to accept one page (page 7) of a specification in an application which was transmitted by Express Mail, but that said page 7 was apparently not received by the PTO.

As more fully set forth in the Declaration, attached, the undersigned certifies that to the best of his knowledge and belief, page 7 of the specification was included in the package of New Application materials sent to the USPTO by Express Mail under mailing label no. EJ770189951US on 2/1/2000.

B. Pursuant to 37 CFR 1.182, the following are submitted:

1. Copy of "Notice of Omitted Item(s) in a Nonprovisional Application"; date mailed: 4/4/2000

2. Declaration of Kent N. Stone (with Attachments, including page 7).

C. **Charges to the Petitioner's Deposit Account # 14-0116 for the following fees are hereby authorized :**

PETITION FEE UNDER 37 CFR 1.17(i).....$130

The Commissioner is hereby authorized to charge an additional fee which may be required to effect the grant of this petition, or credit any overpayment, to Deposit Account No. 14-0116.

D. The petitioner's right to prosecute the application as assignee is established by the three assignment documents filed with the original application, for which petitioner has not yet received the PTO's reel and frame numbers.

Respectfully submitted,

Kent N. Stone

Kent N. Stone, Registration No. 31,883

NASA Glenn Research Center
21000 Brookpark Road
Mail Stop 500-118
Cleveland, Ohio 44135

telephone: (216) 433-8855

****

CERTIFICATE OF EXPRESS MAILING UNDER 37 CFR 1.10

I hereby certify that this Petition to Accept Missing Item in a New Application under 37 CFR 1.182 and the documents referred to enclosed therein are being deposited with the United States Postal Service on this date April 24, 2000, in an envelope as "Express Mail Post Office to Addressee" under Mailing Label No. EJ596690436US, addressed to: Assistant Commissioner for Patents, Box: DAC (Fee), Washington D.C. 20231.

Kent N. Stone

Kent N. Stone, Registration No. 31,883

FORMALITIES LETTER

OC000000005026503

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
Address: COMMISSIONER OF PATENT AND TRADEMARKS
Washington, D.C. 20231

APPLICATION NUMBER	FILING/RECEIPT DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NUMBER
09/498,794	02/01/2000	Kirsten P. Duffy	LEW16,833-1

Kent N Stone
NASA Glenn Research Center
Mail Stop 500 118
21000 Brookpark Road
Cleveland, OH 44135

Date Mailed: 04/04/2000

NOTICE OF OMITTED ITEM(S) IN A NONPROVISIONAL APPLICATION

FILED UNDER 37 CFR 1.53(b)

A filing date has been accorded to the above-identified nonprovisional application papers; however, the following item(s) appear to have been omitted from the application:

- Page(s) **page 7 is missing** of the specification (description and claims).

I. Should applicant contend that the above-noted omitted item(s) was in fact deposited in the Patent and Trademark Office (PTO) with the nonprovisional application papers, a copy of this Notice and a petition (and $130.00 petition fee *(37 CFR 1.17(i))*) with evidence of such deposit **must** be filed within **TWO MONTHS** of date of this Notice. The petition fee will be refunded if is determined that the item(s) was received by the PT

II. Should applicant desire to supply the omitted item(s) and accept the date that such omitted item(s) was fil the PTO as the filing date of the above-identified application, a copy of this Notice, the omitted item(s) (with supplemental oath or declaration in compliance with 37 CFR 1.63 and 1.64 referring to such items), and a p under 37 CFR 1.182 (with the $130.00 petition fee *(37 CFR 1.17(h))* requesting the later filing date **must** be within **TWO MONTHS** of the date of this Notice.

III. The failure to file a petition (and petition fee) under the above options (I) or (II) within **TWO MONTHS** of t date of this Notice (37 CFR 1.181(f)) will be treated as a constructive acceptance by the applicant of the application as deposited in the PTO. **THIS TWO MONTH PERIOD IS NOT EXTENDABLE UNDER 37 CFR 1.136(a) or (b)**. In the absence of a timely filed petition in reply to this Notice, the application will maintain a f date as of the date of deposit of the application papers in the PTO, and original application papers (*i.e.*, the disclosure of the invention) will include only those application papers present in the PTO on the date of depo

In the event that applicant elects not to take action pursuant to options (I) or (II) above (thereby constructivel electing option (III)), amendment of the specification to renumber the pages consecutively and cancel incom sentences caused by any omitted page(s), and/or amendment of the specification to cancel all references tc omitted drawing(s), relabel the drawing figures to be numbered consecutively (if necessary), and correct the references in the specification to the drawing figures to correspond with any relabelled drawing figures, is re Any drawing changes should be accompanied by a copy of the drawing figures showing the proposed chang red ink. Such amendment and/or correction to the drawing figures, if necessary, should be by way of prelimi amendment submitted prior to the first Office action to avoid delays in the prosecution of the application.

Sent to Addressee using Express Mailing label No. EJ 596904436 US on this 24th day of April, 2000.
Kent N. Stone

Encl 1

A copy of this notice MUST be returned with the reply.

Customer Service Center
Initial Patent Examination Division (703) 308-1202
PART 2 - COPY TO BE RETURNED WITH RESPONSE

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of Duffy, et al
Attorney's Docket No. LEW 16,833-1
Serial No. 09/498,794
Filing Date: 02/01/2000
For: "Self-Tuning Impact Damper for Rotating Blades"
Group Art Unit: 3745

DECLARATION OF KENT N. STONE UNDER 37 CFR 1.68

I, Kent N. Stone, declare as follows:

I have checked my file copy of the documents in utility patent application 09/498,794, and conclude that, to the best of my knowledge and belief, page 7 of the specification to the utility patent application serial no. 09/498,794 was included in the package of new application materials which I sent to the USPTO by Express Mail under mailing label no. EJ770189951US on 2/1/2000. I base this conclusion on the following additional facts:

1. I am a patent attorney employed as a civil servant of the United States Government at NASA Glenn Research Center, Cleveland, Ohio.

2. The patent function at NASA Glenn Research Center is tasked to the Office of Chief Counsel.

3. Since May 1995, I have been the only patent attorney at NASA Glenn Research Center. On average, I file about 12 new applications at the U.S. Patent and Trademark Office (USPTO) per year. The application in the instant case, serial no. 09/498,794 was the fourth application I filed in fiscal year 2000.

4. Because of the rather low number of applications I file, and because of the rather modest clerical support the Office of Chief Counsel provides me, I make it a business practice to personally perform all tasks necessary to properly assemble and mail a complete new application package to the USPTO. Hence, for all documents which I intend to include in a new application package, I personally prepare and sign the documents, place stick-on Express Mail labels on the documents, write the mailing label number on the label, prepare a mailing receipt card listing the documents being sent, and photocopy the complete application. Finally, I personally take the complete application package to the Cleveland Airport Post Office for Express Mail service to the USPTO. No clerical assistant is involved in this process.

Encl 2

5. I make it a business practice to file all new applications by U.S. Postal Service Express Mail. I always drive the package to the Cleveland Airport Post Office, which is approximately 3 miles from my office at NASA Glenn Research Center, and personally hand it to the postal clerk, who provides me the customer copy of the completed mailing receipt.

6. I am absolutely certain that the above procedures were followed with respect to all papers I filed for Serial no. 09/498,794. No one, other than myself, photocopied, assembled, or otherwise touched any papers.

7. I distinctly recall the events surrounding the mailing of the application package for serial no. 09/498,794 on February 1, 2000 for the following reasons:

a) On the late afternoon of February 1, 2000 a severe winter snow storm struck Cleveland, Ohio. At about 7:30 PM, after I had completed assembling the Express Mail package containing the new application documents for serial no. 09/498,794, I took the unusual step of telephoning the Cleveland Airport Post Office, to insure it was open. I was afraid the storm may have prevented the evening shift employees from arriving. I was assured the Post Office was open.

b) On the late afternoon of February 1, 2000, the photocopy machine on the hallway of the Office of Chief Counsel, Building 500, NASA Glenn Research Center was out of order. I distinctly recall this because the Chief Counsel himself discovered that some non-staff member had damaged the machine trying to remove their personal insurance papers, which had become stuck in the machine. I was forced to use an identical photocopy machine on the second floor of Building 500 to make my file photocopy of the documents I had assembled for the new application package. That photocopy machine worked fine: I do not recall it jamming or skipping any pages. I remember being relieved that it was in good working order.

8. I specifically recall that the printer for my office personal computer was near the end of the useful life of its toner cartridge when I printed the execution original of the specification and claims for the application in serial no. 09/498,794. It left a horizontal line near the bottom of each page as it printed out. I notice that the pages of the specification of my file copy of the application contain such a line. Hence, my file copy must have been made from the original, because I recall the original bearing such a line.

9. My file copy was made after I had placed the Express Mail labels bearing the mailing label number on the documents. My file copy includes page 7 of the specification. I therefore conclude that the original of page 7 must have been included in the package I sent to the USPTO by Express Mail.

10. Attached are True Copies of my file copies of:

a) Patent Application Receipt mailing card- showing 29 pages of specification and 12 sheets of drawings were sent to the USPTO; I prepared this card myself.

b) PTO Form SB/05 Utility Patent Application-showing 29 pages of specification were sent to the USPTO; I prepared this form myself

c) Application: pages 1-8: page 1 bears the photocopied Express Mail label which I placed upon and signed on the original, and pages 1- 8 all show the horizontal line from the near-exhausted toner cartridge that should appear on the original.

11. I note that my file copy has a staple through the upper left hand corner which did not entirely pierce all the papers. The 29 pages of specification and 12 sheets of drawings are on the outer limits of what my stapler can reliably go through. I speculate it is possible that in transit, the staple could have worked loose and a page was inadvertently reattached at the USPTO to some other set of documents such as the assignments or the Information Disclosure Statement and prior art references which were transmitted with the specification.

12. The page 7 of the specification transmitted herewith is a true copy of the original page 7 which was transmitted with the new application by Express Mail on 2/1/2000.

****

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine and imprisonment or both under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

****

Kent N Stone

Kent N. Stone
Registration No. 31,883

4/24/2000
date

The attached documents are CERTIFIED TO BE TRUE COPIES of the originals filed on 2/1/2000 in a package under U.S. Postal Service Express Mail, Label No. EJ770189951US:

- Mailing receipt card
- PTO SB/05
- Specification, pages 1-8

Kent N. Stone

Kent N. Stone
Reg. No 31,833

Sent to Addressee using Express Mailing label No. EJ 596690436 US on this 24th day of April, 2000.

Kent N. Stone
Kent N. Stone

National Aeronautics and Space Administration

Patent Application Receipt

NASA CASE NO.	: LEW 16, 833-1
FILING DATE	: 2-1-2000
APPLICATION SERIAL NO.	: (TO BE ASSIGNED)
APPLICANT	: Duffy, et al
TITLE	: Self-Tuning Impact Damper for Rotating Blades

RECEIPT OF THE FOLLOWING PAPERS IS EVIDENCED HEREON BY THE OFFICIAL STAMP OF THE UNITED STATES PATENT AND TRADEMARK OFFICE.

- PTO SB/5 - Utility App Transmittal
- PTO SB/17 - Fee Transmittal
- NASA Form 1538 - Declaration, Power of Attny, Petition
- Assignments of Duffy; Brown; Bayley w/2 Recordation Forms, each
- Application - 29 pages specification + 12 sheets drawings
- Info Disc. stat w/ PTO 1449 & 4 patents/articles

NASA FORM 432 SEP 98 PREVIOUS EDITIONS ARE OBSOLETE.

KNS 2-1-2000

Please type a plus sign (+) inside this → [+]

PTO/SB/05 (4/98)
Approved for use through 09/30/2000. OMB 0651-0032
Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 C.F.R. § 1.53(b))

Attorney Docket No.	LEW 16,933-1
First Inventor or Application Identifier	Duffy et al
Title	Self-Tuning Impact Damper for Rotating Blades
Express Mail Label No.	EJ770189951 US

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

ADDRESS TO: Assistant Commissioner for Patents, Box Patent Application, Washington, DC 20231

1. [X] * Fee Transmittal Form (e.g., PTO/SB/17) (Submit an original and a duplicate for fee processing)
2. [X] Specification [Total Pages 29]
   (preferred arrangement set forth below)
   - Descriptive title of the Invention
   - Cross References to Related Applications
   - Statement Regarding Fed sponsored R & D
   - Reference to Microfiche Appendix
   - Background of the Invention
   - Brief Summary of the Invention
   - Brief Description of the Drawings (if filed)
   - Detailed Description
   - Claim(s)
   - Abstract of the Disclosure
3. [X] Drawing(s) (35 U.S.C. 113) [Total Sheets 12]
4. Oath or Declaration [Total Pages 2]
   a. [X] Newly executed (original or copy)
   b. [ ] Copy from a prior application (37 C.F.R. § 1.63(d)) (for continuation/divisional with Box 16 completed)
      i. [ ] DELETION OF INVENTOR(S) Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. §§ 1.63(d)(2) and 1.33(b).

NOTE FOR ITEMS 1 & 13: IN ORDER TO BE ENTITLED TO PAY A SMALL ENTITY FEE, A SMALL ENTITY STATEMENT IS REQUIRED (37 C.F.R. § 1.27), EXCEPT IF ONE IS FILED IN A PRIOR APPLICATION IS RELIED UPON (37 C.F.R. § 1.28).

5. [ ] Microfiche Computer Program (Appendix)
6. Nucleotide and/or Amino Acid Sequence Submission (if applicable, all necessary)
   a. [ ] Computer Readable Copy
   b. [ ] Paper Copy (identical to computer copy)
   c. [ ] Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

7. [X] Assignment Papers (cover sheet & document(s))
8. [ ] 37 C.F.R.§3.73(b) Statement (when there is an assignee) [X] Power of Attorney
9. [ ] English Translation Document (if applicable)
10. [X] Information Disclosure Statement (IDS)/PTO-1449 [X] Copies of IDS Citations
11. [ ] Preliminary Amendment
12. [X] Return Receipt Postcard (MPEP 503) (Should be specifically itemized)
13. [ ] * Small Entity Statement(s) (PTO/SB/09-12) [ ] Statement filed in prior application, Status still proper and desired
14. [ ] Certified Copy of Priority Document(s) (if foreign priority is claimed)
15. [ ] Other: _____

16. If a CONTINUING APPLICATION, check appropriate box, and supply the requisite information below and in a preliminary amendment:
    [ ] Continuation [ ] Divisional [ ] Continuation-in-part (CIP) of prior application No: _____/_____
    Prior application information: Examiner _____ Group / Art Unit: _____
    For CONTINUATION or DIVISIONAL APPS only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 4b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

17. CORRESPONDENCE ADDRESS

[ ] Customer Number or Bar Code Label (Insert Customer No. or Attach bar code label here) or [X] Correspondence address below

Name	Kent N. Stone				
Address	NASA Glenn Research Center Mail Stop 500-118 21000 Brookpark Road				
City	Cleveland	State	Ohio	Zip Code	44135
Country	U.S.A.	Telephone	(216)433-8855	Fax	(216)433-6790

Name (Print/Type)	Kent N. Stone	Registration No. (Attorney/Agent)	31,883
Signature	Kent N. Stone	Date	2-1-2000

Burden Hour Statement: This form is estimated to take 0.2 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Box Patent Application, Washington, DC 20231.

LEW: 16,833-1

SELF-TUNING IMPACT DAMPER FOR ROTATING BLADES

ORIGIN OF THE INVENTION

The invention described herein was made in the performance of work under a NASA contract and subjected to the provisions of §305 of the National Aeronautics and Space Act of 1958, Public Law 85-568(72Stat.435;42U.S.C. 2457).

FIELD OF THE INVENTION

The present invention relates to blades for turbomachinery and, more particularly, to an improved mechanism for dampening vibrations experienced by the blades or disks of turbomachinery so as to extend their operational lives and improve machine performance.

BACKGROUND OF THE INVENTION

Turbomachinery is used in many applications to perform work on or extract work from both gaseous and liquid

fluids. Examples of such machinery include gas turbines, axial and centrifugal fans, marine and aviation propellers, fan blades, helicopter blades, tail rotors, wind turbines, turbo pumps, and steam and hydraulic power turbines. This machinery may contain one or more broad class of rotating and fixed appendages including blades, vanes, foils, and impellers depending on the need of a particular machine.

Turbines and compressor sections within an axial flow turbine engine, as well as other turbomachinery, generally include a rotator assembly comprising a rotating disk and a plurality of rotor blades circumferentially disposed around the disk. During operation, turbine engine rotator assemblies rotate at a variety of speeds through fluid that varies in temperature, pressure, and density. As a result, the blades may be excited in a number of different modes of vibration. Lower order modes manifest themselves in bending modes and torsion modes, whereas higher order modes have more complex blade deformations.

The rotating blades are subjected to resonating conditions as more fully described in U.S. Patent 5,924,845 ('845) which is herein incorporated by reference. As described in the '845 patent, potentially destructive resonant vibration can occur when the frequency of an alternating excitation force imposed on a blade is n ar a

natural, or resonant, frequency of the blade. At these resonant frequencies a blade will experience peak vibrations. A typical blade will have more than one resonant frequency, representing the various modes, or ways, in which the blade can vibrate. For example, a jet engine blade may be viewed as a simple cantilever beam. If an alternating excitation force is imposed on the blade at a resonant frequency corresponding to the first mode, it will simply bend back and forth with one wave along its length. If the excitation frequency is at the second mode resonant frequency, the blade will bend with two waves along its length, and so forth. Modern jet engine blades are more like plates than beams, so that the blades have more complicated vibration modes, including, in addition to conventional bending modes, torsion modes and chordwise bending modes. All of these vibration modes combine to determine the actual resonant frequencies for a turbomachine blade.

Excitation forces in turbomachines arise from time dependent fluid flows. For example, one usual source of an excitation force is the aerodynamic force imposed on a rotor blade each time it rotates past a stator vane (a stationary blade). There will be a number of stator vanes past which the rotor blade will travel during one rotor

revolution, causing the frequency of aerodynamic excitation to be equal to the number of stator vanes multiplied by the rotor speed. This is called engine order excitation. Since there are generally several rows of stator vanes and rotor blades of varying numbers, there are typically many engine order excitation frequencies that a rotor blade will experience. Each of these physical sources of vibratory excitation will cause a different so-called speed line, which is an integer multiple of engine rotor speed.

As first described by W. Campbell in a pioneering 1924 work describing the problems of vibration in turbomachinery, this can be described in a Campbell diagram, where speed lines are plotted on a graph as functions of the rotor speed. Also plotted on the Campbell diagram are the various frequencies at which resonant vibration will occur for each mode of the rotor blade in question. Wherever a speed line, corresponding to a regularly occurring vibratory excitation in a turbomachine, crosses a resonant blade frequency line, resonant blade vibration is possible. This speed line can cross several blade resonant frequencies as the turbomachine speeds up. This means that the excitation frequency on blades will coincide with successively higher resonant frequencies of the blades as rotor speed increases.

Adding one or more dampening devices to a rotor blade will decrease the vibrations and lessen the damage to the blade. In addition, it may allow the turbomachine to be run at a higher speed, improving the efficiency of the machine. Dampening devices may also be added to the rotor disk, which may have vibration modes coupled to the rotor blades. The dampers can then reduce vibrations in the rotor disk and/or the rotor blade.

Rotor blades that are used in axial flow turbines and compressors can be excited to severe levels of vibration when subjected to time-dependent forces as described above. The severe vibrations can damage the material in rotor blades. Devices that absorb and dissipate vibration energy in the blades of rotors in compressors and/or turbines, such as the centrifugal pendulum absorber disclosed in the '845 patent, are known and more of which are disclosed in U.S. Patents 4,182,598; 4,360,088; 4,441,859; 4,484,859; 4,650,167; 5,052,890; 5,232,344; 5,346,362; 5,369,882; 5,498,137; 5,749,705; and 5,820,348 all of which are herein incorporated by reference. It is desired that further improvements for a vibration dampening mechanism for blades be provided.

OBJECTS OF THE INVENTION

It is the primary object of the present invention to provide for a dampening mechanism that absorbs and dissipates vibration energy in the blades or disks of compressors and/or turbines so to extend the service life thereof.

It is another object of the present invention to provide for a dampening mechanism that uses the technique of self-tuned impact dampening.

It is another object of the present invention to provide for a self-tuned impact dampening mechanism that is adjustable to dampen engine-order resonant vibrations along a speed line.

It is a further object of the present invention to provide for a self-tuning dampening mechanism that utilizes a ball-in-spherical trough configuration.

It is a still further object of the present invention to provide for a self-tuning dampening mechanism that can be located internal or external to the blade for which it provides the dampening features so as to extend its operational life.

SUMMARY OF THE INVENTION

This invention is directed to a self-tuning dampening mechanism for a rotating appendage for a turbomachine which absorbs and dissipates the vibration energy in the appendage so as to extend its operational life.

The vibration damper device comprises a member coupled to a rotor having a frequency of vibration with the member being subjected to fluid-flow forces when the rotor is rotated. The member has one or more cavities with walls which confine a rattling mass in each cavity having parameters that are selected in accordance with the anticipated frequency of aerodynamic excitation associated with a speed line on the appropriate Campbell diagram.

In one embodiment, the vibration damper device has a trough configuration having a spherical bottom and a rattling mass, such as a ball, having a resonant frequency that corresponds to the anticipated frequency of aerodynamic excitation.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the nature and objects of the present invention, reference should be made to the

following detailed description taken in conjunction with the accompanied drawings, in which like parts are given like reference numbers, and wherein:

Fig. 1 is a schematic drawing of a turbine wheel with blades and a shaft;

Fig. 2 is composed of Figs 2(A), 2(B), and 2(C), wherein Figs 2(A), and 2(B) schematically illustrate prior art dampening mechanisms, and Fig. 2(C) schematically illustrates the self-tuning impact damper mechanism of the present invention;

Fig. 3 illustrates a Campbell diagram showing speed lines and resonant frequencies plotted against rotor speed;

Fig. 4 illustrates a two (2) degree-of-freedom system;

Fig. 5 illustrates various curves associated with tuned mass amplification factor calculations;

Fig. 6 is composed of Fig. 6(A) and 6(B) that respectively illustrate the amplification factor calculation curves and damping factor calculation curves associated with the self-tuning impact damper of the present invention;

Fig. 7 illustrates response curves associated with the tuned mass damper effectiveness;